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BULLETIN 252 MAY, 1916

SPRAYING EXPERIMENTS AND APPLE DISEASES IN 1915

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*In collaboration with U. S. Department of Agriculture.

BULLETIN 252

APPLE SPRAYING EXPERIMENTS IN 1915.*

W. J. Morse.

The 1915 apple spraying experiments at Highmoor Farm, as in the past, were conducted with the Ben Davis variety. The number of trees involved was 216, or 9 plots of 24 trees each. Each plot consisted of 4 parallel rows of 6 trees to the row. The trees are now between 25 and 30 years old and those used for experimental purposes are in a fairly uniform and vigorous condition.

Treatment of the Plots.

The following is the spraying treatment outlined for each separate plot. The dates of application are given on p. 171.

Plot 1. Standard dilution lime-sulphur, plus one pound of dry arsenate of lead in 50 gallons.†

Plot 2. Blossom bud application omitted, otherwise like Plot 1.

*The present publication constitutes the sixth annual report of results obtained from a series of apple spraying experiments at Highmoor Farm. Previous reports may be found in Bulletins 189 (1911), 198 (1912), 212 (1913), 223 (1914), and 240 (1915) of this Station. For the first two years these experiments were conducted by Mr. W. W. Bonns, then Station Horticulturist, but since then they have been under the general supervision of the writer. They are planned to cover an indefinite series of years, the object being to secure data regarding sprays and their effects upon the apple as influenced by Maine conditions. A summary of the results obtained during the six successive seasons will be found in Bulletin 249 of this Station.

†By standard dilution is meant the equivalent of 1 gallon of a 33° B. lime-sulphur concentrate diluted with 40 gallons of water. For a 20 per cent stronger dilution, one-fifth more of the concentrate was used for making a given amount of spray than was used for making the standard dilution.

Plot 3. Blossom bud application lime-sulphur 20 per cent stronger than standard, plus one pound of dry arsenate of lead to 50 gallons; later applications two pounds of dry arsenate of lead alone in 50 gallons of water.

Plot 4. Blossom bud application 3-3-50 bordeaux mixture, plus one pound of dry arsenate of lead in 50 gallons; later applications like those on Plot 3.

Plot 5. All applications dry arsenate of lead alone, two pounds in 50 gallons of water.

Plot 6. All applications extra fine sulphur 10 pounds, dry arsenate of lead 1 pound, water 50 gallons.*

Plot 7. All applications 3-3-50 bordeaux mixture plus 1 pound of dry arsenate of lead in 50 gallons.

Plot 8. Treatment like plot 1, plus a previous application of dormant strength lime-sulphur *after the leaf buds began to open,* but the buds still small and the young leaves closely imbricated.

Plot 9. Unsprayed check.

Plots 1, 7 and 9, sprayed with standard dilution lime-sulphur, bordeaux mixture, and unsprayed respectively, were introduced as checks upon which to make comparisons in judging the results obtained upon the other plots.

Plot 2 was used to test, in comparison with plot 1, the efficiency of the spray application made when the blossom buds are showing pink. Omitting this application in previous experiments had by no means always resulted in a material increase in the amount of scab on the leaves and fruit. This part of the experiment has now been carried on for four successive seasons.

Plots 3 and 4 represent a modified spraying practice which previous work in connection with this series of experiments suggested as applicable to Maine conditions. The idea is to use a strong fungicide combined with a moderate amount of arsenate of lead when the blossom buds are showing pink, but for later protection both against apple scab and chewing insects to depend entirely on arsenate of lead,—using a larger quantity for subsequent applications.

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*For method of preparation see page 180 of Bulletin 240 of this Station.

Plot 5 was a continuation of previous work, the object being to test the fungicidal properties of arsenate of lead in controlling apple scab.

Plot 6 was a repetition of an experiment conducted the previous year.

Plot 8 was introduced largely to determine how much injury might be expected from the application of dormant strength lime-sulphur after the leaf buds had begun to open, or at a later period than it is customary to use this material. It has been demonstrated previously at this station, where young McIntosh trees showed an abundance of limb infection from the season before, that a dormant strength lime-sulphur applied just as the leaf buds were swelling, but before they opened, materially reduced the amount of scab on the leaves the following summer.* While, as far as the writer is aware, so long a delay in applying the dormant strength lime-sulphur has been advised or recommended by no one, even for limb infection for apple scab, the Station receives numerous inquiries each year as to whether or not it may be done with safety. These usually come from orchard owners who have purchased materials in order to spray for blister mite, scale insects, etc., but who, for one reason or another, have failed to do so at the proper time.

Time and Manner of Spray Applications.

All the sprays were applied with a gasoline power sprayer at a pressure of from 150 to 200 pounds per square inch, using a nozzle which delivered a fine mist. Especial care was taken to see that each tree was thoroughly covered with the spray at each application, but not enough material was applied to cause excessive dripping. After each plot was sprayed the spray tank, pump, hose and extension rods were thoroughly rinsed in clean water.

The dormant spray on plot 8 was applied on May 3. At this time the blossom buds appeared well protected. The young leaves surrounding them were not over one-third of an inch long, frequently less, and closely imbricated.

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*Morse, W. J., and Darrow, W. H. Is apple scab on young shoots a source of spring infection? Phytopathology 3:265-269, Oct., 1913.

Morse, W. J. Spraying experiments and apple diseases in 1913. Bul. Me. Agr. Exp. Sta. 223:20-23, Jan., 1914.

All the other applications were made to all of the plots on the same day. The first was made on May 14 just as the blossom buds were showing pink, the second on June 3, immediately after the petals fell, and the third on June 21.

The dormant strength lime-sulphur was prepared on the basis of a 1 to 8 dilution of a 33° B. concentrate, the summer strength on the basis of a 1 to 40 dilution of the same material.

Effect of the Different Sprays on the Foliage and Fruit During the Summer.

The development of scab. As will be shown later in the tabulated results obtained from sorting the fruit, scab was not severe even on the unsprayed trees. Undoubtedly early cultivation of the orchards last season materially assisted in reducing the amount of early spring infection. On May 3, the date of the late application of the dormant spray, a considerable number of scab infested leaves of the season before were gathered from under the trees and were taken to Orono for examination. At this time only immature asci or spore sacs could be found. These leaves were moistened, and then placed in covered, porous flower pot saucers, the latter being partly sunk in the soil out of doors to prevent drying out and to keep the leaves as near under natural conditions as possible. Under these conditions the spores in the asci were still immature at the time of the first application of the fungicidal spray on May 14, and did not reach maturity till 4 or 5 days thereafter. The orchards had been quite thoroughly plowed, and the fallen leaves of the season before turned under before May 14, so that it was impossible to secure fresh material at that time to determine what the actual conditions were in the field. However, since the temperatures at Orono during this time averaged higher than at the farm, it is not probable that the spores developed any more rapidly there. Hence it would seem that the early plowing whereby the leaves were turned under the soil before the ascospores of the scab fungus were mature and were able to bring about the first spring infection may partly account for the small amount of scab on the unsprayed plot.

Although frequent examinations were made, usually once a week, up to about August 1, no scab was observed on the leaves till July 28 when a small amount was found on both

leaves and fruit on the unsprayed check plot and an occasional affected leaf was seen on the trees sprayed with the extra fine sulphur. No scab was observed on the leaves of any of the trees on the remaining plots then or later in the season.

Records were kept during the season as to the appearance of scab on the fruit on the different plots, but these contain nothing of value which is not given in the tabulated results of the condition of the fruit at harvest time.

Spray injury during the summer. On a few nights about May 15 the minimum temperature recorded at the farm was only slightly above freezing. These low temperatures at one time at least were accompanied by strong winds, and resulted in considerable foliage injury, more particularly on the northwest sides of the trees. This made it difficult in some instances to determine just how much of the injury should be attributed to the spray. Also late in the season a certain amount of scorching and browning of the leaves, resembling injury due to weather conditions, was observed all through the orchards. This was less, however, on the unsprayed trees than on the other experimental plots and the remainder of the orchards.

Plot 8, sprayed on May 3, with dormant strength lime-sulphur, after the leaves surrounding the bud clusters had begun to show, did not give any evidence of spray injury for at least 3 days. On May 7 very slight traces of burning of the buds began to appear. The leaves of the latter had grown but slightly in the meantime but on this date the margins of some of them had begun to turn brown, particularly at the tips. One bud was found where the entire outer leaves were browned. On May 10, one week after the spray was applied it was apparent that the young leaves on fully 50 per cent of the smaller and more tender buds had been injured. When compared with those on unsprayed trees, they showed a decided checking in growth. The buds at this time were fully double the size that they were on May 7, the cluster leaves being from one-half to three-fourths inch long and the enclosed blossom buds being in some instances one-eighth inch or more in diameter. As far as could be determined then the injury was confined to the outer leaves and did not effect the blossom buds within.

On May 14 the evidences of injury were rapidly disappearing. In some instances it was quite evident that the flower bud

clusters were injured more or less and occasionally the flower buds were killed except the central one or two in the cluster. On May 25, or about three weeks after the dormant spray was applied, the evidence of injury had so largely disappeared that a person not knowing about it would not notice it in passing through the orchards. However, on some trees where the worst injury was noted quite a number of bud clusters could be found where all but the central bud had been destroyed. From the early part of June and following, the trees on this plot appeared as healthy as any of the others, although the leaves were a little smaller at first. The amount of fruit which finally set was apparently fully as much on the average as on other trees which did not receive the late dormant spray. It was noticed early in the season that the fruit on this plot showed considerable russeting.

As usual the plot sprayed 3 times with bordeaux mixture showed a large amount of spray injury. By June 15 numerous leaves showed spotting and quite a percentage were turning yellow and falling. Russeting of the fruit was apparent when the latter was quite small.

Spray injury was also later recorded on the leaves of the trees on plot 4 where a single early application of bordeaux mixture was applied, followed by double strength arsenate of lead for later applications. On July 1 it was noted that some of the leaves were turning yellow and falling. A careful examination on July 8 indicated that spray injury, though common on the leaves, was not severe. *It was, however, by no means confined to those leaves which had been formed before the single application of bordeaux mixture was made.* No such injury could be found on the adjoining plot where the double strength arsenate of lead alone was used for all applications.

Throughout the season no differences with regard to spray injury could be detected on the remainder of the plots, including plot 3 which received a blossom bud application of lime-sulphur, 20 per cent stronger than standard. A very slight amount of injury undoubtedly occurred but this was complicated with the frost injury of the early spring and the leaf scorch of late summer which made it difficult to decide how much of the trouble should be ascribed to each factor.

The Effect of the Different Sprays on the Fruit.

It has been the custom in the past to harvest the apples on the experimental plots some time during the first 10 days of October and then immediately sort them into three classes—the smooth or perfect apples; those which are scabby; and those which are russeted or show spray injury. In 1915 a heavy wind took over half the crop from the experimental trees on the night of September 26. These apples were immediately picked up and sorted, but the remainder were not harvested and sorted till October 6 and following.

As has already been mentioned the plots in each case consisted of four rows of 6 trees each. For sorting for the purpose of record it is the custom to take only the fruit from the 12 trees which constitute the two inner rows, limiting the sample to 20 barrels for each plot in case the crop on the two central rows exceeds this amount. In this way the effects of spray blowing from one plot onto another, receiving a different treatment, is largely eliminated.

In the instance under consideration it also eliminated the danger of mixing the samples from the different plots in the case of the apples blown off by the wind.

The following, Table 1, (page 176) is a summary of the results obtained from sorting and counting the number of fruits on each of the different plots.

Discussion of Results.

The fact that scab developed in such a slight degree on the experimental plots in 1915, even where no spray whatever was applied, makes the results regarding its control less valuable than those obtained in certain previous years.

Efficiency of the First Spray Application.

In this discussion the spray application made just before the blossom buds open is the one under consideration. In the case of lime-sulphur it refers to the first application made with the material diluted to summer strength. This phase of the experiment in which a comparison of two plots, numbers 1 and 2 in 1915, sprayed exactly alike except that on one of them the first application when the blossom buds were showing pink was omitted, has been going on for four years. In 1913 and 1914 the differences in the amount of scab resulting from such

TABLE I.

Summary of Results Obtained from Sorting Fruits.

Plot.	TREATMENT.	Total number of apples.	Number smooth.	Number scabby.	Number russeted.	Per cent of perfect apples.	Per cent of scabby apples.	Per cent of russeted apples.	Difference in per cent of russeting as compared with check.
1	Standard dilution lime-sulphur plus 1 pound of dry arsenate of lead to 50 gallons	9,164	8,197	12	955	89.45	.13	10.42	6.84
2	Blossom bud application omitted, otherwise like plot 1	7,794	7,089	11	694	90.96	.14	8.90	5.32
3	Blossom bud application, lime-sulphur 20 per cent. stronger than standard, plus 1 lb. of dry arsenate of lead in 50 gallons. Calyx and one later application, 2 lbs. of dry arsenate of lead in 50 gallons of water	4,742	4,606	13	123	97.13	.27	2.59	.99
4	Blossom bud application 3-3-50 bordeaux mixture plus 1 lb. of dry arsenate of lead in 50 gallons. Calyx and one later application like plot 3	7,406	6,434	36	936	86.87	.49	12.64	9.06
5	Dry arsenate of lead alone, 2 lbs. to 50 gallons of water	8,748	8,530	37	181	97.50	.42	2.07	1.51
6	Extra fine sulphur alone, 10 lbs., plus 1 lb. of dry arsenate of lead to 50 gallons of water	8,190	7,837	54	299	95.69	.66	3.65	.07
7	Bordeaux mixture 3-3-50 plus 1 lb. of dry arsenate of lead to 50 gallons	4,987	1,068	4	3,915	21.42	.08	78.50	74.92
8	Treatment like plot 1, plus a previous application of dormant lime-sulphur *after the leaf buds* had begun to open	9,659	7,536	2	2,121	78.02	.02	21.96	18.38
9	Unsprayed check	4,798	4,386	240	172	91.41	5.00	3.58	-

omission of the first spray were only slight and probably within the limits of experimental error. In one case there was slightly more and in another slightly less. In 1912, or the first season in which the experiment was carried out, quite striking results were obtained showing the value of the first application.

In 1915 scab was controlled equally well on both plots, it being reduced in each instance, when compared with the check plot from 5 per cent to a little over one-tenth per cent. As has already been mentioned it was not possible to determine just when the ascospores of the scab fungus reached maturity in the orchard on the fallen leaves of the season before, but it was plainly some days after the application of the first fungicidal spray, or the one omitted on plot 2, as shown by laboratory studies of the material collected and taken to Orono.

The evidence secured on this point in the past plainly indicates that the omission of the application when the blossom buds are showing pink may result in a large increase of scab. On the other hand the results of the past season again show that no orchardist should fail to carry out the remainder of the season's spraying program, if for any reason the first application was omitted.

Lime-sulphur vs. Bordeaux Mixture.

As has already been stated plots 1 and 7, sprayed with these two materials, in connection with the unsprayed check, form the basis for determining the relative merits of the other spray combinations used. It is of interest to note, however, that upon a variety of apples like the Ben Davis where both the foliage and fruit are particularly susceptible to spray injury lime-sulphur continues to show marked superiority. Scab control in each case was nearly perfect, but on account of russeting of the fruit less than 22 per cent of perfect apples were obtained from the use of bordeaux mixture, while over 89 per cent of the same grade of fruit was secured where lime-sulphur was used.

Another fact worthy of comment is that in this season where only a small amount of scab developed on the unsprayed check the amount of russeting produced by the lime-sulphur itself more than offset its beneficial results in scab control, for over 91 per cent of perfect apples were obtained on the check plot.

It is only fair to state in this connection that this is the first time such a result has been secured in these series of experiments since an unsprayed plot has been introduced as a check.

Arsenate of Lead as a Fungicide.

While the conditions for the past season were not such as to make the test of the fungicidal properties of the various sprays in any way a severe one the results obtained with arsenate of lead in controlling apple scab were in general confirmatory of those previously obtained. Where this material was used alone on plot 5 the amount of scab on the fruit, as compared with the check plot was reduced from 5 per cent to less than half of one per cent. This is the fourth consecutive season in this orchard in which the use of arsenate of lead on experimental plots at the rate of 4 pounds of paste or two pounds of the dry powder alone in 50 gallons of water has been followed by a material reduction of the amount of scab on the crop. One of the striking results obtained from the use of arsenate of lead alone on the Ben Davis, as shown by these experiments, is the relatively small amount of russeting of the fruit. Consequently, as will be seen on reference to the table, the plot sprayed in this way gave the largest percentage of perfect apples of any in 1915, or 97.50 per cent. In this connection attention is called to the fact that practically the same record was made on plot 3 which received lime-sulphur 20 per cent stronger than standard dilution combined with one pound of dry arsenate of lead in 50 gallons for the first application, and for the last two sprayings two pounds of dry arsenate of lead alone in 50 gallons of water.

While the evidence of apple scab control in the field by means of arsenate of lead appears quite conclusive some unpublished results secured by the writer's associate, Mr. M. Shapovalov, indicate that, while it is much retarded, the growth of the apple scab fungus in artificial culture media is by no means prevented when arsenate of lead is added to the culture medium at the same rate at which it was used in water for spraying. Similar results were obtained in germinating the spores of the fungus in pure, distilled water and carbonated water in comparison with other spore germination tests where arsenate of lead was added to the same liquids.

Arsenate of Lead Alone for Calyx and Later Applications.

The use of a strong fungicide for the first foliage spray followed by double strength arsenate of lead alone, as applied to plots 3 and 4 in 1915, has been tried for two successive seasons. Again, as in 1914, conditions were such that it is impossible to draw conclusions relative to the advantages derived from the use of the strong fungicidal spray instead of arsenate of lead alone for the first application. This is due to the fact that omitting the first application of standard dilution lime-sulphur entirely on plot 2 was not followed by any increase in scab as compared with plot 1 which was sprayed three times with the same material. Apparently scab control in 1915 came largely from the two later applications. Also the differences in amounts of scab recorded on plots 3 and 4 when compared with plot 5, sprayed with arsenate of lead alone, are within the limits of experimental error. However, the results obtained on plots 3 and 4 tend to conform those secured on 5 and similar plots of previous years relative to the fungicidal action of arsenate of lead. They also add to the evidence that, under the climatic conditions which existed in 1915 as well as in 1914, the first fungicidal spray application had little to do in the prevention of apple scab.

Again, as in 1914, an application of 3-3-50 bordeaux mixture on plot 4 before the flower buds opened resulted in leaf injury and increased fruit russeting. It is difficult to explain why some of this injury should occur. As has already been pointed out the injury was not confined to those leaves already formed when the bordeaux mixture was applied, and the amount of russeted fruit, as compared with the check, was increased about 9 per cent. Since the apple fruit is morphologically an enlarged and thickened calyx tube it is evident that a strong spray applied before the blossom buds open may and does reach tissues which later develop into the the skin of the fruit. Hence, there is a possibility that it might cause injury then which would appear as russeting later. Attention is called to the fact, however, that as is shown below an application of winter strength lime-sulphur to plot 8 at an earlier date when the blossom buds were still all surrounded and protected by young leaves led to somewhat more russeting of the fruit than was recorded upon

plot 4. It hardly seems possible that the calyx tubes could have been injured sufficiently at the time of spraying with the strong lime-sulphur to account for all of the russeting experienced.

From a practical standpoint it is evident that bordeaux mixture cannot be safely used on the Ben Davis, even for the first spray application before the blossom buds open. On the other hand it is equally evident from the experience of several seasons that the amount of lime-sulphur concentrate in a given amount of spray used for this first application may be increased 20 per cent without fear of appreciable leaf injury or of increasing russeting. It will be noted that there was less russeted fruit on plot 3, sprayed in this manner, than there was on the unsprayed check. In this respect it agreed with plot 5 which had arsenate of lead alone for all 3 applications.

Late Application of Dormant Strength Lime-sulphur.

It seems improbable that an application of dormant strength lime-sulphur would be of material benefit in controlling apple scab except in cases of the over-wintering of the fungus on young twigs. This, however, in Maine according to the writer's observations is confined to the McIntosh and a few other varieties which are particularly susceptible to scab. Therefore, especially since no scab has ever been observed on the limbs of the Ben Davis at Highmoor it was not surprising that the difference in the amount of scab obtained in sorting the fruits on plots 1 and 8 was only about one-tenth of one per cent, or plainly within the limits of experimental error.

As has already been stated the use of the strong lime-sulphur on plot 8, after the buds had enlarged sufficiently so that the young leaves were beginning to show, caused very apparent injury at the time, but no permanent ill effects were observed on the foliage or in the reduction of the amount of fruit set. On the other hand reference to Table 1 shows that only about 78 per cent of merchantable fruit was obtained on plot 8 as compared with over 89 per cent on plot 1 which was sprayed exactly the same, except it received no dormant spray application, this difference being entirely due to the increase in russeting on the former.

Plot 8 consisted of trees 7 to 12, rows 11 to 14. The record given in Table 1 is for the fruit harvested on the two central

rows, 12 and 13. Row 11 adjoined plot 7 on the south, sprayed throughout the season with bordeaux mixture. Row 14 came next to the unsprayed check on the north. The question arose with reference to plot 8 whether the increased russeting might result from spray drifting across from the plot sprayed entirely with bordeaux mixture. A like situation occurred in 1914 with the plot sprayed with bordeaux mixture for the first application, which was similarly located with reference to another plot sprayed throughout the season with the same material. That season, however, the increase in russeting on the plot receiving only one application of bordeaux mixture was not discovered till all the fruit was harvested and the sorting had been begun.

No differences could be observed, before harvesting, in the amount of russeting of the fruit on the different rows of trees on plot 8 in 1915. If any such differences did exist, due to the spray drifting across from the adjoining plot, it would seem that row 11, the nearest, should show more and row 14, the farthest removed from plot 7, should show less russeting than the two central rows. Accordingly the fruit on these two outside rows was harvested and sorted separately. The results obtained as far as they apply to russeting are given in Table 2 along with similar data with reference to rows 12 and 13.

TABLE 2.

Russeting of Fruit on Plot 8.

	Total number of apples.	Number russeted.	Per cent. russeted.
Row 11, nearest plot 7	2,786	516	18.52
Row 14, nearest plot 9	2,713	610	22.48
Rows 11 and 14, combined	5,499	1,126	20.48
Rows 12 and 13 (Plot 8, Table 1)	9,659	2,121	21.96

It is evident from the above figures that the bordeaux mixture applied to plot 7 was in no way responsible for the increased amount of russeting on plot 8. It will be seen that the fruit on the row nearest the bordeaux sprayed plot showed less russeting than that farthest removed or nearest the unsprayed

check plot, also that the amount of russeting on it is less than on the fruit on rows 12 and 13 which were used for making the record given for plot 8 in Table 1. Other factors apparently being eliminated it would seem that the application of the dormant strength lime-sulphur, after the leaf-buds had begun to open, but at a time when the flower-buds were still quite thoroughly protected was in some way responsible for the increased amount of fruit russeting observed later. Regardless of the cause of the russeting there appears to be no advantage from the standpoint of scab prevention in applying the dormant spray later than is usually recommended for scale and similar insects.

Extra Fine Sulphur.

How efficient this material would be for scab control, when applied to apple trees in the manner described in this publication, during a season in which the disease is particularly severe, cannot be predicted from the experience with it during the past two seasons. That it possesses very evident fungicidal properties is shown by the fact that scab on the fruit produced on plot 6, when compared with the check was reduced from 5 per cent to a little more than one-half of one per cent.

WINTER INJURY OF YOUNG APPLE TREES FOLLOWING SETTING IN DYNAMITED HOLES.

W. J. Morse.

Of the two original Baldwin orchards on the farm, one was so far gone through a combination of neglect, and the direct and indirect effects following the severe winter of 1906-7 that it was removed soon after the Station took control in 1909. The other, though very unpromising, was retained, largely for the purpose of determining what might be expected from reclamation work upon other orchards similarly injured and neglected. A certain proportion of the trees in the last named orchard failed to recover and were removed from time to time. In the early spring of 1913 the places formerly occupied by 150 of these were filled by setting young Baldwin trees.

In the case of 126 of these trees, they were set where holes had been blasted with dynamite the fall before. With these 52 other trees, similar in every respect, were set in the same orchard in the usual manner by digging a hole with a shovel. In both cases, whether dynamited or not, a large hole was dug and filled in with top soil to where the tree was to be set. This was necessary in both instances for the primary object of the dynamiting was to shatter the subsoil rather than simply to make a hole. As far as the location of the trees in the orchard was concerned, conditions were ideal from an experimental standpoint. Since they were to replace trees which had been removed from different parts of the orchard for one cause or another, chance rather than design determined where the young trees should be placed. Consequently they were scattered indiscriminately through the orchard, those in dynamited and shovel dug holes mixed in with no particular order.

As first outlined this experiment was in no way concerned with pathology and the writer had no part in planning or carrying it out and knew nothing of the former treatment of the individual trees previous to collecting the records with regard to the winter injury upon them. The work was undertaken at the instance of one of the large firms which manufacture explosives and the dynamited holes were made by one of their experts. The primary object of the experiment was to determine whether or not the trees would make a better or more vigorous growth

where the subsoil had been shattered with dynamite. As far as could be judged no difference in this respect occurred for good growth was made both seasons and in the fall of the second year, 1914, all of the trees appeared uniformly vigorous and healthy.

Before taking up the discussion of the injury which occurred during the winter of 1914-15 a brief statement should be made with regard to the character of the soil in the orchards and the method followed in dynamiting.

The soil on the farm is a moderately heavy, reddish loam, underlain by a very compact subsoil. In the orchard in question the surface soil contains rather more sand and is consequently somewhat lighter than most of the remainder of the farm which is devoted to similar purposes. Regardless of the presence of the sand the subsoil is quite impervious to moisture, and according to the farm superintendent, runs only from 7 to 15 inches below the surface. The topography of the orchard is such that for the most part a gentle slope to the west provides good surface drainage. The only soil pockets where water was likely to stand or where the surface drainage was poor have been underlaid with tile.

In blowing holes for setting the young apple trees the charge of dynamite was inserted at a depth of from 30 to 36 inches. The material encountered toward the bottom of the holes consisted of a resistant hardpan which was very difficult to break and required one stick of extra 20 per cent dynamite. The expert reported as follows regarding a test hole put down to a depth of 36 inches and loaded with one cartridge. "This blew but a small amount of dirt out of the hole. A man was put to work digging out the loose material, and we found there was very satisfactory loosening to a depth of 36 inches with lines of breakage extending in all directions from the point of the shot." In writing of digging into another hole on similar soil on another part of the farm he said: "This shattering seemed to dip slightly upward in all directions."

In the spring of 1915 it was evident that a considerable number of the young apple trees had suffered severely from winter injury. Many were killed back to within 12 to 18 inches of the ground while some appeared dead, nearly or quite to the soil line. In the latter part of June, when it was felt that the full

extent of the injury was apparent, the writer made a careful examination of each tree and recorded its condition at that time.

In taking this record it was evident that there was no relation between the location of individual trees in the orchard and the amount of winter injury observed, but some quite striking results were obtained when these observations were tabulated in comparison with the method used in setting the trees. Out of 126 trees set in holes previously dynamited, 49 or nearly 39 per cent were either winter killed or badly injured. Of the 52 trees set in shovel dug holes, only 4 or less than 8 per cent suffered in like manner.

No attempt is made to draw general conclusions from these figures obtained in a single orchard. What happened here might not, and probably would not occur under different soil conditions. Nevertheless it would seem evident that the method of setting trees in dynamited holes is not adapted to soil conditions like those on this farm. Based on the results where the trees were set in shovel dug holes the probable loss from winter injury among the entire 178, had they all been so set, would be approximately 14 trees. Similarly had all the trees been set in dynamited holes, the expected loss would be about 69.

TWO APPLE-LEAF TROUBLES NEW TO MAINE.

W. J. Morse.

In the summer of 1915 two foliage troubles of the apple were observed, of which there appears to have been no previous record in this state. One of these, which the writer has called chlorosis, was widespread and common in a single orchard and occurred to a certain extent on individual, scattered trees in the same locality. No definite cause could be assigned to the condition. The other, a disease previously reported in Europe, Canada, South Africa and New Zealand, is known as silver-leaf and was found to be fairly common in various parts of the orchard growing section of the State.

Chlorosis.

In September, 1914 some diseased apple leaves were received through the college of agriculture from their extension representative in Franklin county, Mr. W. M. Morse. At that time the trouble was known to exist on a single tree, growing by the roadside in Livermore Falls. Further observations by Mr. Morse in the spring and early summer of 1915 showed that this condition of apple foliage had a wider distribution than was first indicated, and led to a visit to the locality by the writer under his guidance.

As far as observed this chlorotic effect on the leaves was limited to apple trees in a rather restricted area of adjoining portions of the towns of Jay and Livermore. Although several more or less isolated affected trees, including Baldwin, Northern Spy and Harvey varieties were seen which were growing on high, well-drained land under good conditions, observations in Jay were confined principally to a single orchard of Baldwins of two or three acres in extent. This orchard was on rather low land, naturally moist, but was fairly well drained with open ditches. The leaf trouble was restricted to no particular part of the orchard but was apparently not quite so severe on the higher portion. However, the trees here were somewhat younger than the rest. The majority of those affected were probably 25 to 30 years old and may have been older. While they had apparently been neglected up to a few years ago their treatment in this respect did not differ from that given to the trees in many other orchards in which no

such trouble occurred. For the past few years they have been cultivated, fertilized and pruned.

The trouble appeared on the younger as well as the older branches and is in no way connected with the normal yellowing and falling of the inner and more shaded leaves which is of common occurrence. Neither is it associated with any form of spray injury for it occurs on sprayed and unsprayed trees alike. However, leaves so affected are easily and sometimes severely injured by lime-sulphur, used at a dilution which gave absolutely no injurious effects on the healthy foliage of the same tree.

The leaves showing the chlorosis here described are, as a rule, variously spotted or mottled with irregular splashes of yellow, giving a variegated appearance. No opportunity was afforded to follow the course of the disease through the season, but it is thought that the yellowing is progressive, eventually involving a large part if not the whole of the leaf, for some were collected which showed but little of the original green remaining.

Figures 26 and 27 illustrate the appearance of the affected leaves much better than any written description. The portion of the young branch represented in Figure 26 gives an idea of the characteristic appearance of the diseased foliage on the tree. The leaves shown in Figure 27 were selected to show individual variations. The two on the extreme left of this illustration are far from typical of the great majority and represent about the only specimens of this character found, out of probably more than one hundred collected. While the yellowing appears to start frequently along the line of the larger leaf-veins it is just as likely to appear first in the tissues midway between them.

In the preliminary studies made in the field no definite clue could be obtained as to the cause of the trouble. Conditions in this part of the state during the growing season of 1915 were decidedly abnormal, being characterized by excessive rainfall, associated with a large amount of cool, cloudy weather. The following facts are against the unreserved acceptance of the theory that weather conditions and the location of the orchard were the prime contributing factors in bringing about the condition observed. The disease was present the previous season; it occurred in the same locality on several varieties represented

by scattered trees on high, well-drained soil, and was not found elsewhere under similar conditions.

Dried specimens showing the more common characteristics of the affected leaves were sent to three recognized experts in plant pathology in other states, asking if they had previously seen the trouble and if they could give any information as to its cause.

Dr. G. P. Clinton of Connecticut replied as follows: "On page 360 of my 1914 report on chlorosis of plants, I mentioned a chlorosis trouble of apples that I have occasionally seen. This trouble is not quite like the one sent in that I have only rarely seen it attacking the leaves of small branches, and the chlorosis areas on the leaves are more elongated and whiter than those you sent."

Had Doctor Clinton seen the two leaves shown at the left of Figure 27 it is possible that he might have wished to qualify this statement. However, the writer is convinced that he is correct in this opinion that the trouble found in Maine is distinct from the one observed by him in Connecticut.

Prof. F. C. Stewart of New York made these comments: "In our bulletin 328, page 318 you wil find a brief account of the apple mosaic or variegation which you mention. From your description and the specimen sent I am confident that the two ar identical. I kno nothing about the cause of the trouble and hav made no other observations on the effect of spraying such leaves."

In the publication mentioned* Professor Stewart records under the heading of "Variegated Foliage" the occurrence of this trouble on apple trees in four different parts of the state of New York at various times from 1896 to 1910. In the earliest observed case one tree had practically all the foliage affected for two successive seasons. An adjacent tree which showed the variegation the first year on one of its branches was entirely free from it the second. One apple tree is mentioned on which certain branches show variegated leaves year after year.

The third lot of diseased leaves was sent to Dr. L. R. Jones of Wisconsin. The reply came from Dr. G. W. Keitt who

*Stewart, F. C. Notes on New York Plant Diseases I. Bul. N. Y. Agr. Exp. Sta. 328:318, 1910.

stated that neither he nor Dr. Jones had seen any apple injury in that state which closely resembled this.

Silver Leaf.

As far as the writer has been able to learn the only references to this disease in American literature are contained in the writings of Güssow. In 1910 he recorded its presence in Nova Scotia.* In giving the characters of the disease he mentioned that the leaves on the affected branches have a silvery appearance or a milky-white gloss, particularly on the upper surfaces. The epidermis on the upper surfaces of the leaves is also very brittle. In this paper he states that when a branch is attacked it dies, as a rule, after one or two years and that a tree once attacked by silver leaf will eventually succumb. In this paper he mentions that some European writers consider the disease to be physiological but says that it is remarkable that *Stereum purpureum* Pers. is constantly associated with it.

In a second paper‡ he states that it is known by him to exist from Nova Scotia to Vancouver Island and expresses his surprise that none of it should be recorded across the border when it is evident that so many cases exist in Canada. At this time he reported that he had only observed the disease on apples and plums in Canada, but mentions the fact that pears, peaches, cherries, currants and gooseberries are also attacked by silver leaf. He cites experimental evidence of his own and others, particularly in England, tending to connect the cause of the disease with *S. purpureum*.

In still a third paper† he reports more fully on the disease, giving the results of inoculation experiments which lead him to conclude that it is caused by *S. purpureum*. Therefore, as a control measure he would advise the destruction by burning of all diseased branches and fully diseased trees. Any dead apple wood including stumps in the orchard which might serve as a breeding place for the fungus, which he looks upon as a wound parasite, should be burned.

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*Güssow, H. T. Silver leaf. Report Dominion Botanist, Dept. of Agric. Canada, 1910. p. 268.

‡Güssow, H. T. A preliminary note on silver leaf disease of fruit trees. Phytopathology 1:177-179. Dec. 1911.

†Güssow, H. T. Der milchglanz der obstbäume. Ztschr. Pflanzenkrank. 22:385-401. 1912.

Observations made last summer indicate that in all probability silver leaf is as common on apple trees in Maine as it is in the adjoining portions of Canada. On account of its frequently inconspicuous appearance, and partially from a lack of familiarity with the characteristic symptoms of the disease, on the part of those who are interested in matters of this kind, it has not been recognized previously.

The writer's attention was first called to this abnormal condition of apple foliage by Dr. L. R. Jones of Wisconsin during a visit of the latter to Maine in the summer of 1915. Doctor Jones stated that he had previously had opportunity to observe the trouble in company with Professor Güssow. It was at once evident that the true "silver leaf," as it occurs in Maine, is a much less conspicuous trouble than certain cases reported from Canada. Nothing has yet been seen which would conform to the following sentence. "Some of the trees are so silvery in appearance that their abnormal condition is apparent from a great distance."

Instead of being silvery the diseased foliage had a distinct, dull, leaden, metallic luster. The name "plomb" used to designate the disease by the French seems more applicable to the cases observed in Maine. While trees showing this condition may be overlooked by the average individual, the abnormal appearance of the affected leaves is sufficiently marked so that they are readily detected a short distance away by anyone who has become familiar with the characteristic symptoms. When the diseased and healthy leaves are placed side by side the differences are apparent to any observer.

The writer was unable to collect any confirmatory evidence last season relative to *S. purpureum* being the cause of the disease. It was observed that every tree or branch which showed silver leaf also presented some slight evidence of winter injury resulting from the season immediately preceding. This fact was quite evident at Highmoor Farm where practically all of the cases were confined to one or more limbs on an affected tree, but never involving the whole tree. *S. purpureum* was not observed on any of these trees, but it follows winter injury of apple trees in Maine with great regularity.

FURTHER OBSERVATIONS RELATIVE TO THE ABILITY OF THE APPLE SCAB FUNGUS TO LIVE OVER WINTER ON YOUNG TWIGS.

W. J. Morse.

Mention has already been made on p. 171 to observations made at this Station which indicated that the scab fungus *Venturia pomi* (Fr.) Wint. was able to remain alive over winter in infected young apple twigs and that viable conidia found in the pustules produced by the fungus on these twigs are at times a source of spring infection on the leaves.

In the spring of 1913 when these observations were made a large number of specimens were received from various parts of the State. In a number of instances where the conidia of the fungus were still present, germination tests made in prune decoction and prune agar indicated that they were still living. Practically all of these tests were with material obtained from diseased limbs collected in March and April. Pure cultures made from the spores thus obtained, agreed in every respect with those of *V. pomi*. Inoculations of young apple trees growing in the greenhouse with spores produced in these cultures resulted in the production of typical cases of apple scab on the leaves.

While references to the over-wintering of apple scab on the twigs are by no means lacking in European literature the writer was unable to find any previous record of similar observations in America. In fact the general consensus of opinion among pathologists in this country as expressed by their writings appeared to be quite the contrary. Therefore, it seemed worth while to continue these observations as opportunity offered. While no such an abundance of material has been obtained since the spring of 1913 additional data has been secured each year.

In 1914 one specimen was received in January and two in February. In each case a few spores were found but not in sufficient abundance to make germination tests. Specimens received from one of the coast towns in the eastern part of the State on April 15 carried sufficient spores so that positive germination tests were made in prune decoction.

A few specimens of diseases twigs bearing spores were received during March and April, 1915, but no germination tests were made.

On March 31, 1916, a few affected twigs were received from another town on the coast. These also carried an abundance of spores which readily germinated in distilled water. Another supply of material from the same source, obtained a week later, likewise gave similar results. Under the climatic conditions which exist in Maine this was about one month before the leaf buds on the apple trees would begin to enlarge and growth to start. Moreover up to within about three days before the specimens were collected the ground was covered with over a foot of snow. While it is of little practical importance whether these spores, since they are found to be viable in the spring, were produced the fall before or were formed in the spring or late winter from living mycelium growing in the bark on the limbs, it hardly seems possible that the latter should be the case in the present instance.

The first opportunity to extend these observations to scab infections on pear limbs came in May, 1916. Some specimens were received which were collected just before the leaves started in which the young twigs were bardly affected with scab and carried an abundance of the conidia of the fungus. These spores also readily germinated in distilled water.

It may be of interest to state that while other varieties of apples have been found affected and specimens have been obtained from the interior of the State a great proportion of the affected twigs came from McIntosh trees, and from towns on or near the coast.

Fig. 26. A small apple branch bearing leaves affected with chlorosis.

Fig. 27. Individual apple leaves showing variations in chlorotic effect. The type represented by the two at the extreme left was rare.